

Rapid Prototyping during NATO Experimentation in Support of the Enhanced CIMIC Integrated Capability Team

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ABSTRACT

As part of its ongoing effort to encourage rapid prototyping within NATO, the Allied Command Transformation Modelling and Simulation Section is actively involved in modelling and simulating at the multinational political/military level. Experimentation with multinational political concepts and at the military strategic level is inherently complicated and sensitive. Simulation can be used to not only rapidly prototype concept changes but also to derisk the cultural sensitivities that may be associated with live experimentation.

During the NATO Crisis Management Exercise 06, conducted 1-7 March 2006, the Modelling and Simulation Section provided models and simulations, which aided concept developers conducting experimentation and studies. This paper will describe in detail the Crisis Management Exercise simulation effort and briefly explain the main follow on M&S effort which is different in nature.

The primary experiment known as the NATO HQ Crisis Management Fusion Centre had an overall aim to enable decision coherence and included several sub-objectives. Extend™ was used to simulate the concept and highlight metrics and areas for improvements. Due to the immediate significant need to provide improvements in the Enhanced CIMIC Transformational Objective Area, several follow on activities have begun including a separate modelling effort that was initiated dealing with information collaboration between NATO elements and Non-Governmental Organisations and International Organisations. This information collaboration is being modelled and simulated at all levels from strategic to tactical and across the policy, planning and operations domains. The goal is to create a synthetic environment in a battle laboratory where new procedures can be developed cooperatively to improve the civilian-military relationship during operations. This follow on effort is quite different from the first rapid prototype development effort but still uses several of the lessons learned to steer its progress.

1.0 INTRODUCTION

Allied Command Transformation (ACT) has embraced modelling and simulation (M&S) as one of its most powerful tools to enforce and accelerate the transformation process. Innovative concept development coupled with successful operational experimentation can speed the delivery of valid and credible capabilities for NATO. By encouraging the imaginative use of M&S in developing those concepts needed to promote Alliance goals, ACT is fostering the transformation of capabilities in NATO.

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ACT is using families of complementary models and simulations to aggressively promote prototyping and innovatively speed concept development. Simulations are being developed to rapidly test concept ideas and to generate discussion, encourage evaluation of tradeoffs, and better define the specifications for more detailed concept definition and development. Concept development follows a spiral path - the simulations are developed to capture initial concepts and ideas, the concepts are tested using simulation to identify improvements, and then the simulations are modified to reflect the improvements and another round of testing begins. The simulation may be conducted in concert with operational experimentation and used as an analysis tool to produce data and to further insights.

There are significant ongoing efforts related to prototyping new concepts within NATO at the political/military level. The first example in this paper deals with the business process modelling of an innovative new concept being developed for NATO HQ, the Crisis Management Fusion Centre (CMFC). The second example is the creation of a CIMIC Synthetic Environment for further on going concept development. Beginning with a background description of the experimentation conducted during the past three Crisis Management Exercises (CMX), this paper will then describe M&S efforts in the CMFC and on going effort related to the synthetic environment. The paper will show that inexpensive commercial M&S tools can be used to quickly and effectively build concept prototypes to provoke discussion and debate as well as to zero in on capability solutions at all levels in NATO. The paper will further show that these commercial tools can be used in conjunction with more expensive and complicated tools to provide a robust simulation environment.

1.1 Background

Over the past two decades, the Nations of the NATO Alliance have each faced dramatic changes in the international environment and the context within which they pursue security. Today's threats of international terrorism, failed states, and the proliferation of weapons of mass destruction are far different from the threat envisioned during the Cold War. NATO now conducts operations and assistance around the world to support global stability.

ACT is a strategic command established to deal with military related security challenges and to explore technologies, organisations and processes that would help transform Alliance capabilities to support operations. In exploring new ways of operating, employing emerging technologies, or using established technologies in new and different ways, the Alliance can address these security challenges in innovative ways. Without operational responsibilities, the command can focus on its role as a "forcing agent for change," leading to the continuous improvement of Alliance capabilities to uphold NATO's global security interests and to ensure that the Alliance has the most effective capabilities at its disposal.

Once a year, CMXs provide a venue to validate or test new and evolving crisis management organisations, arrangements, procedures, measures and communications. The exercises are the sole opportunity for National and NATO political, military, and civil emergency authorities to simultaneously and collectively exercise the current political/military consultation and decision-making process within the Alliance. Experimentation differs from an exercise construct in that it is focused on future and potential capabilities, whereas exercises are usually geared towards training and familiarising participants with current processes and systems. However, ACT is heavily involved in ensuring that exercises at all levels of warfare are used also for experimentation purposes, including CMX.

Experimentation during CMX04 was very much a discovery experience. ACT recruited 10 very senior retired military and diplomatic persons to work as "Senior Concept Developers." These experts used their extensive connections to interview senior national delegation and NATO staffs in order to determine principle

challenges facing NATO HQ that could realistically be tackled by ACT. The answer was overwhelmingly focused on the continuing need for decision coherence (in CMX04 it was still identified as decision superiority). NATO HQ needed to share information in a timelier manner in order to achieve this decision coherence. After a thorough review of the findings, ACT took on the task of developing a solution to this pre-eminent challenge.

2.0 THE CRISIS MANAGEMENT FUSION CENTRE

The major experiment in CMX05 was the Crisis Management Fusion Centre. Although it was in many ways simple, raw and unsophisticated, the CMFC proved that using a web portal as a central node to receive, evaluate and post in one place all of the information related to a particular crisis was exceedingly valuable and powerful. It should also lead to greater decision coherence. The current procedure within NATO HQ is for information dealing with a crisis to be sent to the crisis registry by an authorised source, and the registry then forwards the information to one or several distribution lists of perhaps several hundred people. This can result in an individual receiving upwards of 200 emails a day, many of which do not pertain to the staff member's role in the crisis.

The CMFC is an information and knowledge management organisation that consists of a small team of between 15 and 20 people who monitor, collect and process all relevant information available on a crisis and disseminate that information via a website called the NATO Strategic Overview (NSO). The NSO can be monitored by anyone able to access NATO's secret level network including staff in the Nations' capitals. The central element is the fusion cell which is responsible for creating a coherent and intuitive crisis picture on the NSO. In the experiment they did this by intercepting all registry emails and parsing them to determine whether the emails should be sent to a functional cell (political, military and civil), whether the information is so vital that it should be posted immediately, or whether the information is not really that important and should just be stored. Any attachments are automatically copied to the CMFC document handling system and are accessible by all. As shown in Diagram 1, the political, civil and military functional cells consist of subject matter experts (SMEs) who can do additional work on the correspondence including preparing summaries and connecting related information items. The CMFC is not meant to replace intelligence functions or intelligence analysts. During CMX06, held 1-7 March 2006, the CMFC experimentation was similar to that conducted in 2005 except that it was much more refined and focused while taking advantage of an M&S capability.

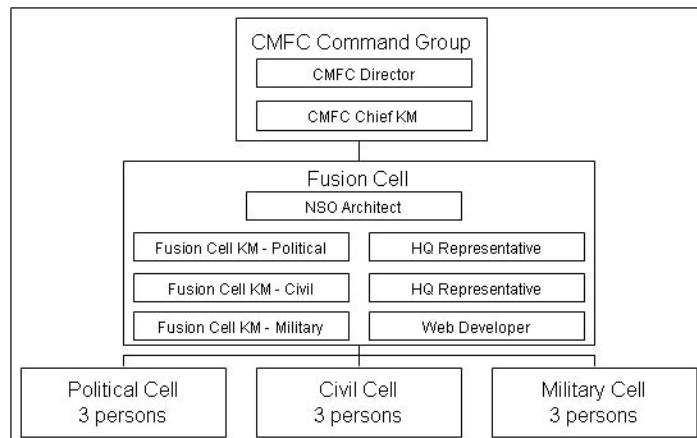


Diagram 1. Crisis Management Fusion Centre Organisation Chart

2.1 CMFC M&S

The ACT M&S Section is a relatively new group rapidly coming into its own within the NATO Capability Development Process. Although the CMFC experiment was well supported in 2005 and 2006 by analysts from ACT and the Nations, the newly formed M&S Section did not become involved until late in the development of the CMX06 planning in September 2005. The concept was already well advanced by this time but when approached, the experimentation team recognised the power of the simulation tools and welcomed the chance to have feedback on their concept design.

A common process followed in developing a simulation is; understand the problem, build an “as is” model, develop a new concept, build the “to be” model, verify the model, populate with data, and validate the model. It should be stressed that in the ACT approach to rapid prototyping, steps can be skipped or run concurrently without prejudice in order to hasten the prototype delivery. The important idea is that the model can be used to improve the concept immediately by invoking and provoking discussion. A software that supports all of these ideas is ExtendTM which ACT has selected to use as its business process simulation software.

During initial discussions with the stakeholders of the operational experimentation team and the concept developers, it became clear that although the concept developers had developed a new concept for how information was fused in NATO, they did not have a good idea of how much better it was than the previous method. They were no previously agreed metrics to measure their success or failure other than best judgment. So, now there was a starting point. After two meetings, it became clear that the main metric of success should be the number of postings that were made to the NSO over various periods. In other words, how much more information may crisis participants have with the new concept than they may have had with the old concept?

As the metric was the number of postings, a model was built that looked at what percentage of time the analysts spend during the day doing different tasks such as: searching, fusing and posting information; taking breaks; discussing with their colleagues; and how much time they were actually at work. A simulation was made from the model and shown to the concept developers and members of the Operational Experimentation Branch who thought that it would be of value to their work. However, in the CMX planning structure the concept developers needed to report to the Concept Development and Experimentation Syndicate during the final planning conference. As the concept had already progressed to a stage where it needed to be validated by this larger audience, the simulation did not invoke any further discussion with the concept developers in order to help them visualize it and make concept improvements. At this stage the concept was just too advanced to be influenced.

At the final planning conference, the simulation was shown and provoked a lot of discussion on the value of the concept, what metrics were to be used to measure success, and the actual processes being developed in the concept. At last, success! The conclusion at the end of the initial session was that the model that was built did not capture any of the information that this larger concept development audience thought was important. They wanted the model to focus on business practices dealing with the information. In particular, they wanted statistics on information delivery times, throughput, cycle times, and the location of bottlenecks and recommendations to improve the process. The Syndicate meeting adjourned on a Friday afternoon and was to start again the next Monday morning. A new model and simulation were built in twelve hours over the weekend. When shown the new model as depicted in Diagram 2, the Syndicate was enthusiastic in their response that this model could be used to develop the concept further.

CMX is an exercise and as such is used to simulate real life. As with most scripted military exercises the event consists of a scenario with injects by a directing staff to which the participants must respond.

Simulations built for this environment will be inherently different from real life. This was taken into account during the model construction and enough hooks were built into the simulation to allow it to also be used in a real life situation.

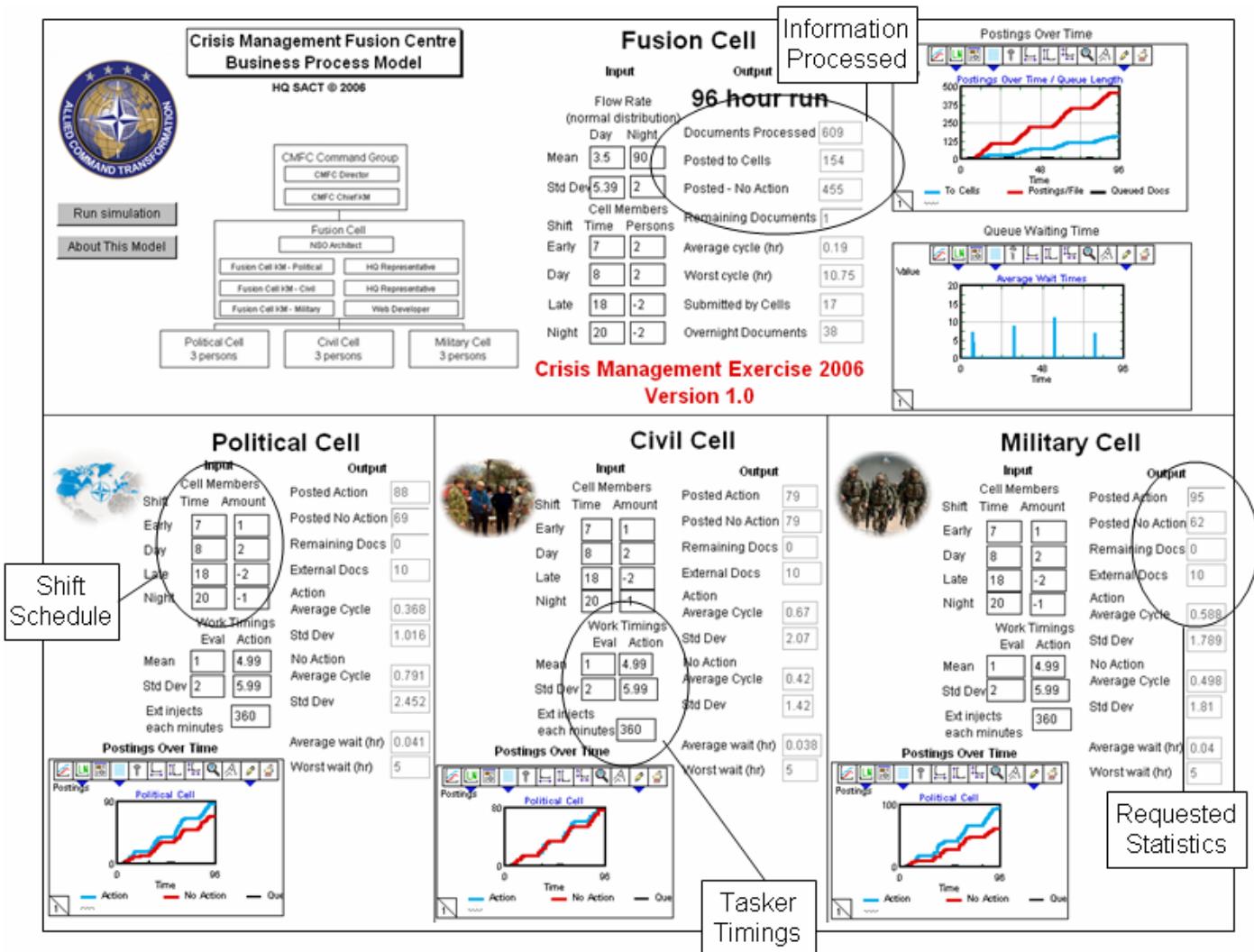


Diagram 2. Screenshot of the Crisis Management Fusion Centre Simulation

The data that was used to initially populate the model was untrustworthy as it was based on the memory of participants from the CMX05 experiment and another limited objective experiment conducted at NATO HQ in September 2005. There was no accurate data on which to validate the model, so the data had to be collected during CMX06. The data that needed to be collected included arrival rates of email messages and other taskers such as phone calls, and how long the messages or taskers took to be actioned. There was no automated method to collect the data and the information technologists could not find a solution to capture the data. After a day of trying other methods, analysts collected the required information via survey sheets. This actually had the effect of forcing the analysts to pay very close attention to the detail of what was going on in the cells for which they were responsible. The result was that the simulationist got accurate data for the model and the other analysts were able to describe in much more detail the actual working of their cell.

During the exercise, there was an opportunity to corral the concept developers and oblige them to verify the model. This was done on about day four of the seven-day exercise and was revealing in not just that the model described correctly the CMFC processes but that the concept had actually evolved during the exercise and was now slightly different in terms of individual cell and personnel responsibilities than what had been previously agreed and written into the concept. It is very difficult to capture data and do a proper analysis when the participants and concept developers change the concept midstream without warning. However, this is a good example of exercise reality where the Nations demanded the change to improve their abilities. In fact, it helped validate the concept. It may also have proven beneficial to have tested the concept improvement in the simulation before going live so as to gather insights on what may be expected.

When the tasker data had been collected, it was analysed using @Risk™. Over a three day period there was about a thousand pieces of data collected. Feeding the data into @Risk™ and allowing it to suggest a distribution is a significant time saving activity and allowed the model to be continually updated with better data. This does not alleviate the simulationist the responsibility to ensure that the distributions and other data used are correct. The suggested distributions need a sanity check before using them in the simulation. Once the proper data was in the model, it could be validated.

For this uncomplicated model, the validation was fairly straightforward and done with the assistance of other analysts. There was no independent validation done so the results may be considered subjective. Various techniques were used to validate the model including:

- Using the built in animation capabilities to display information graphically as the model moved through time which is similar to tracing which was also used.
- Using operational graphics to display various performance measures including wait times and other queuing data.
- Using degenerate tests to determine the model's behaviour by appropriate selection of values of the input and internal parameters.
- Using event validity where the “events” of occurrences of the simulation model were compared to those of the real system to determine if they were similar (they were).
- Using extreme condition tests where the model structure and output should be plausible for any extreme and unlikely combination of levels of factors in the system.
- Using fixed values variables to check the results against calculated values.

During the hot wash at the end of the exercise, the simulation was used to look at some, “what if” situations and the actual M&S portion of the concept development process was discussed with the other analysts. Extend™ allows a simulationist to share his simulation with others at no cost via a downloaded Extend player and the simulation runtime libraries. This is a very powerful feature as it allowed the other analysts to take a copy to use in their home Nation to describe the work that they had been doing.

The previous paragraphs clearly show that ACT has embraced M&S as a method to aid in rapid concept development. But, ACT is still adopting business practices at all levels including concept development, experimentation, and analysis. The next section of this paper will illustrate how ACT is also building synthetic environment capability to support the Enhanced CIMIC Integrated Capability Team (ICT).

3.0 CIVIL MILITARY RELATIONS

During CMX05, one of the discovery experiments that were conducted dealt with NATO's interactions with non-governmental organisations (NGOs) and international organisations (IOs). Within military operations, there is a need for the military to establish a relationship with civilian authorities and other non-combatants in the same theatre of operations. Traditionally this interaction has been called civil military cooperation or CIMIC. Under this construct the military shares information to ensure that military operations can be optimised and that civilian casualties are minimised. The information sharing often does not flow well both ways. Due to changes in the global environment, the increase in peacekeeping operations and in the number of non-state actors, there is a need to share greater quantities of information between NGOs, IOs, and the military. The ability to interact and share information is essential to develop a sense of shared situational awareness, which is a first step on the Enhanced CIMIC roadmap. The ACT Operational Experimentation team is addressing these shortfalls through the use of information and knowledge management tools, M&S, and other techniques and processes that have proven useful for crisis management at NATO Headquarters. It is the enhanced situational awareness which is most important as this will then lead to self-synchronization and de-confliction of the engagement space.

3.1 Civil Military Experimentation

As a result of the recommendations that were made during CMX05 and insights gained during CMX06, ACT has embarked on an experimentation campaign to develop and experiment with a family of concepts to improve the sharing of information between all parties involved in the theatre of operations. During CMX06, two dedicated workshops were held in Brussels to help understand the CIMIC challenge. Members of the International Staff which supports the North Atlantic Council and the International Military Staff which supports the Military Committee attended the first workshop. The goal of this meeting was to identify and get buy in from stakeholders and begin to understand the problem. The second workshop was held with members of the CIMIC ICT, operational experimentation team, a Senior Concept Developer, scientists from the NATO Consultation, Command, and Control Agency (NC3A), and a representative of the ACT M&S Section. The goal of this workshop was to build an outline CIMIC Concept Development and Experimentation Campaign to be conducted over the next several years. The CIMIC ICT provided the general vision guidance and objectives regarding information sharing in the near and mid future. NC3A provided advice on emerging technology that would be needed to provide information sharing tools. M&S provided advice on how to move forward in modelling the technical and more ethereal aspects of CIMIC. The Operational Experimentation team collected the inputs and produced a campaign that is well supported by the ACT leadership who recognise the value and resulting rewards of this CIMIC work. The primary goal of the campaign is to increase information sharing among all civil and military involved in operational areas whether it be as a result of war, peacekeeping, or disaster.

3.2 Civil Military Modelling

After the two kick-off workshops held during CMX06, several informal discussions were held with members of the International Staff and International Military Staff who regularly deal with IOs and NGOs. During the discussions, it became evident that although the branches that were visited were aware of other branches of the NATO HQ staff who dealt with the same organisations they were not necessarily aware of what the other Branch's information sharing requirements were or what related information they should share internally between NATO HQ Branches. Interviews with CIMIC experts indicated that similar opportunities for improvement existed at the tactical level as well.

These interviews and other information gathered indicated to the experimentation and simulation staffs that the lack of a coherent, overarching and agreed concept to share information could only be tackled with a team approach supported by the appropriate resources. It was decided that as a mid range goal the team would put into place a CIMIC synthetic environment by mid 2007 for experimentation. The environment is expected to be accessible by NATO, Nations, NGOs, and IOs alike. It was further decided that the method by which this environment would move forward would be in collaboration with an ongoing NATO Industrial Advisory Group (NIAG) Battlespace Laboratory study.

The NIAG is conducting a study on behalf of ACT to investigate how NATO could more efficiently and effectively work with industry and use industrial battlespace laboratories to conduct M&S work. A contract has been let to a European firm to develop the required synthetic environment. Working in close cooperation with the concept development and experimentation staff the contractor is gathering information and using the DODAF architecture to ensure that the models will be easily understood. The “as-is” model will need to be representative in nature as it would never be possible to model all of the hundreds of NN-IOs, and nations who may be involved in any particular theatre of operations. During summer 2006, the team conducted several more interviews and held additional workshops to gather information. Several Nations, IOs and NGOs have joined the effort and are actively helping to develop future concepts.

As part of the NIAG battlelab study the CIMIC synthetic environment work will be demonstrated at the ACT Industry Day 2006, 2-3 September in Paris, and the Concept Development and Experimentation Conference, 30 October – 2 November in Athens. The M&S will further be demonstrated at the NATO Summit in Riga, Latvia later in November.

The Enhanced CIMIC M&S work is off to a great start with key stakeholders enthusiastic in their response to the idea of modelling the information sharing and using those models to build simulations in support of concept development.

4.0 SUMMARY

This paper has shown two examples of where M&S is being used within the ACT Concept Development and Experimentation process. The first example of running simulations of the CMFC suffered minor problems primarily associated with M&S becoming involved in the concept development late in the planning. The second modelling example of CIMIC information sharing illustrates a much more comprehensive approach where M&S is an integral component of the concept development and experimentation campaign and in fact forms the basis for collaborative work with outside partners.

Both the CMFC and the CIMIC examples identify several lessons that can be used to ensure that future M&S work will continue to provide NATO with the transformational capabilities that it needs for the future. The following lessons were identified:

- Speedy innovation is required to accelerate the transformation process within NATO and the Alliance nations. Rapid prototyping using inexpensive M&S tools such as Extend™ can help to achieve speedy innovation.
- Concept developers need to be made aware of the potential benefits of early involvement of M&S in their concept development work. As a method to help visualise the developing concept and to provoke debate and discussion, M&S can be a powerful tool.

- M&S can be used in all concept development work including that at the political/military level and when there is a lack of verified information.
- Concept developers can be shown the drag and drop process building blocks of the model while it is being developed to help them visualise their concept.
- Stakeholders need to be aware of the benefits of M&S and what their involvement in the concept development and experimentation process will be. Workshops and other meetings can be used to facilitate the stakeholder buy in.
- During experimentation, the simulationists should be integrated with other analysts in order to ensure that they are supportive of each other in their data collection and analysis tasks.
- Exercises are different from real life and the artificiality of the situation can have a severe effect on the simulation. Models and the resulting simulations must be built to be flexible enough to exist in any expected environment.
- During experimentation, concepts can be changed ad hoc in real time to reflect good ideas but, this may have higher value and reduce the risk if the concept change is run within the simulator beforehand.
- The ability to share the simulation with all analysts and allow them to take a runtime version to their home laboratory for demonstrations can be a powerful motivator for them to develop their own rapid prototyping capability.

5.0 CONCLUSION

ACT has embraced M&S as one of its most powerful tools to enforce and accelerate the transformation process. As was seen in the paper, by encouraging the imaginative use of M&S in developing those concepts needed to promote Alliance goals, ACT is fostering the transformation of capabilities in NATO.

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5 October 2006



Rapid Prototyping During NATO Experimentation
In Support of the Enhanced CIMIC Integrated Capability Team

Act Vision

"We are NATO's forcing agent for change, leading the continuous improvement of Alliance capabilities to uphold NATO's global security interests."

Standing Priorities

- Transform NATO's military capabilities.
- Prepare, support and sustain Alliance operations.
- Implement NATO Response Force and other deployable capabilities.
- Achieve ACT full operational capability.
- Assist transformation of partner capabilities.



Rapid Prototyping During NATO Experimentation
In Support of the Enhanced CIMIC Integrated Capability Team

Prototypes & Simulations Drive The Innovation Process

“The notion that innovations can be studied or analyzed into existence flies in the face of history and fact. How serious can any study or risk analysis of a proposed innovation be if its authors haven’t played with the options, alternatives, and trade-offs.”

Michael Schrage, *Serious Play: How the World’s Best Companies Simulate to Innovate*



Rapid Prototyping During NATO Experimentation
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Simulation Prototyping

- The quick and dirty prototype is a medium of co-development
- Instead of a specification driven prototype, we use prototype driven specifications!
- The value of prototypes lies in the interactions they generate – the conversations, collaborations & arguments.



Rapid Prototyping During NATO Experimentation
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Crisis Management Exercise

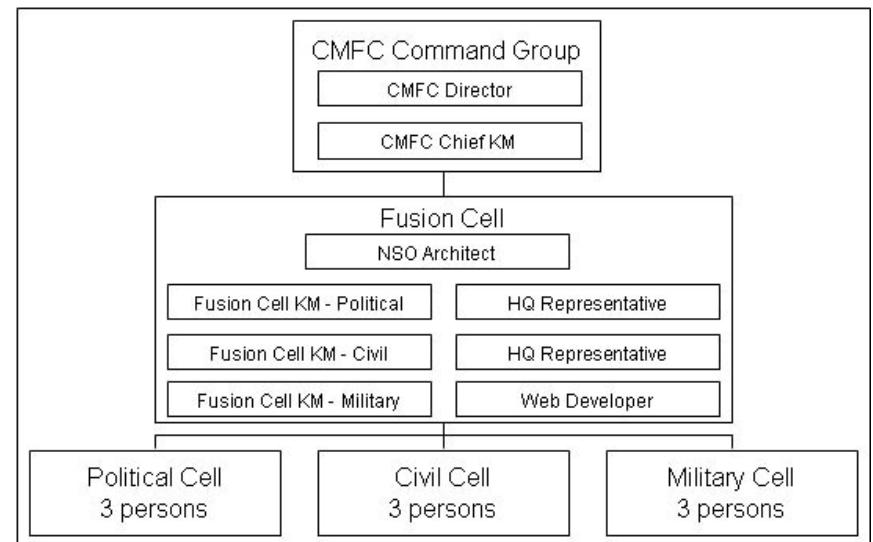
- NATO's only political military exercise
- All 26 National capitals and some partners participate
- About 18 months of planning through five conferences. All aspects of planning are based on consensus
- Event includes
 - Seven days and three decision cycles
 - Experimental objectives
 - Personal attention of Secretary General, senior committees and Nations



Rapid Prototyping During NATO Experimentation
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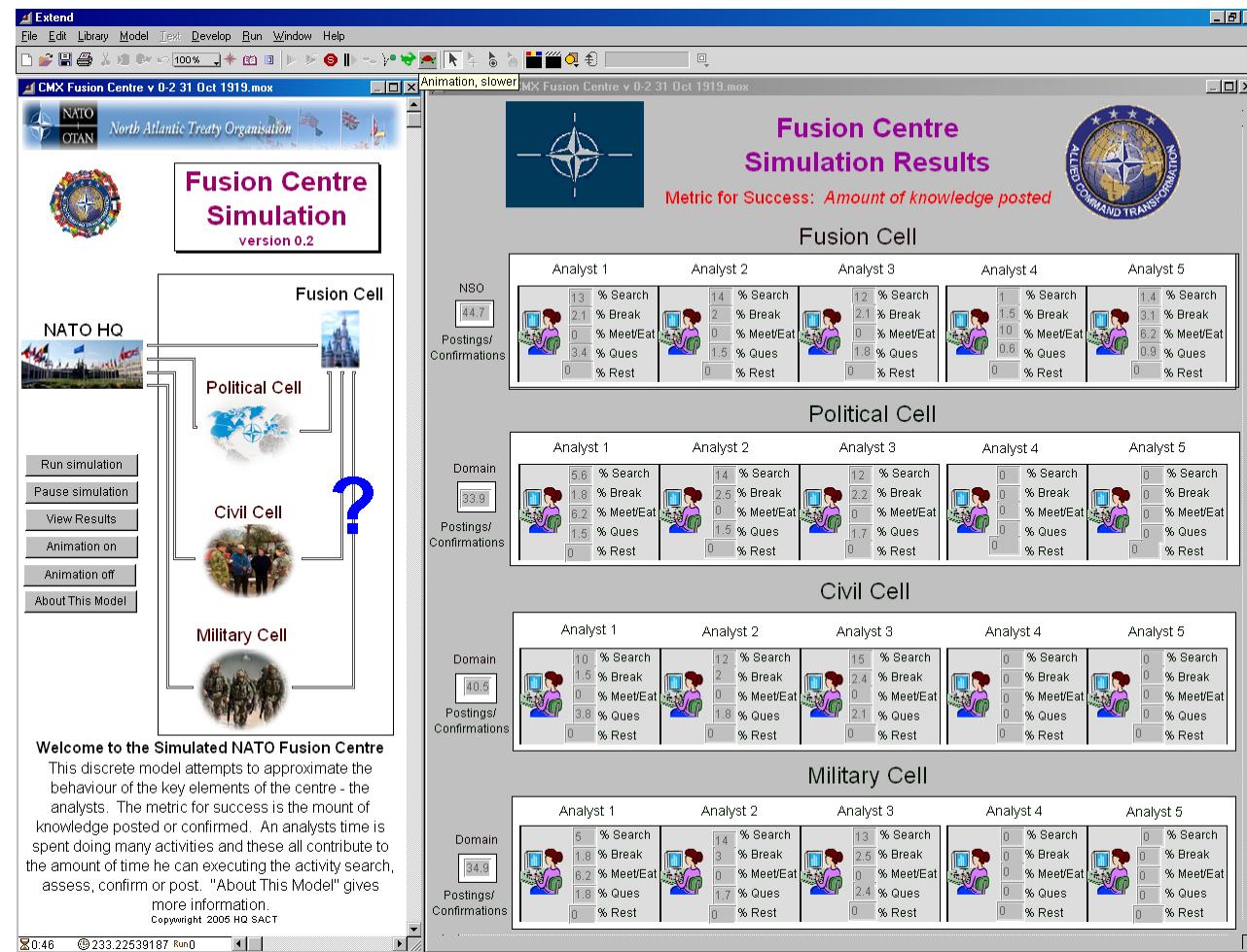
Crisis Management Exercise Experimentation

- Crisis Management Fusion Centre was main experimental objective in 05 and 06
- 64 experimenters from ACT and Nations
- Civil military relationships also investigated



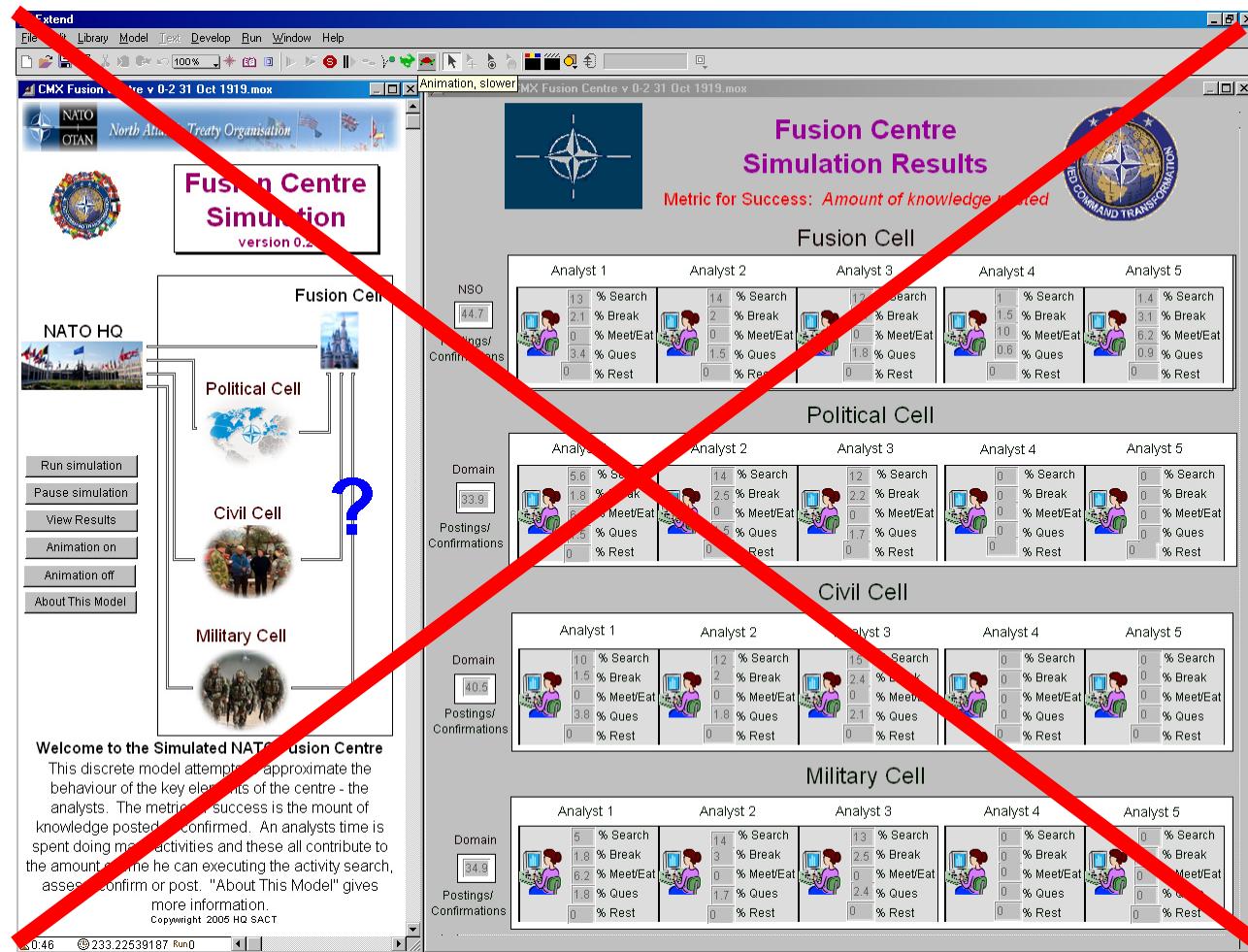
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Crisis Management Fusion Centre Model and Simulation



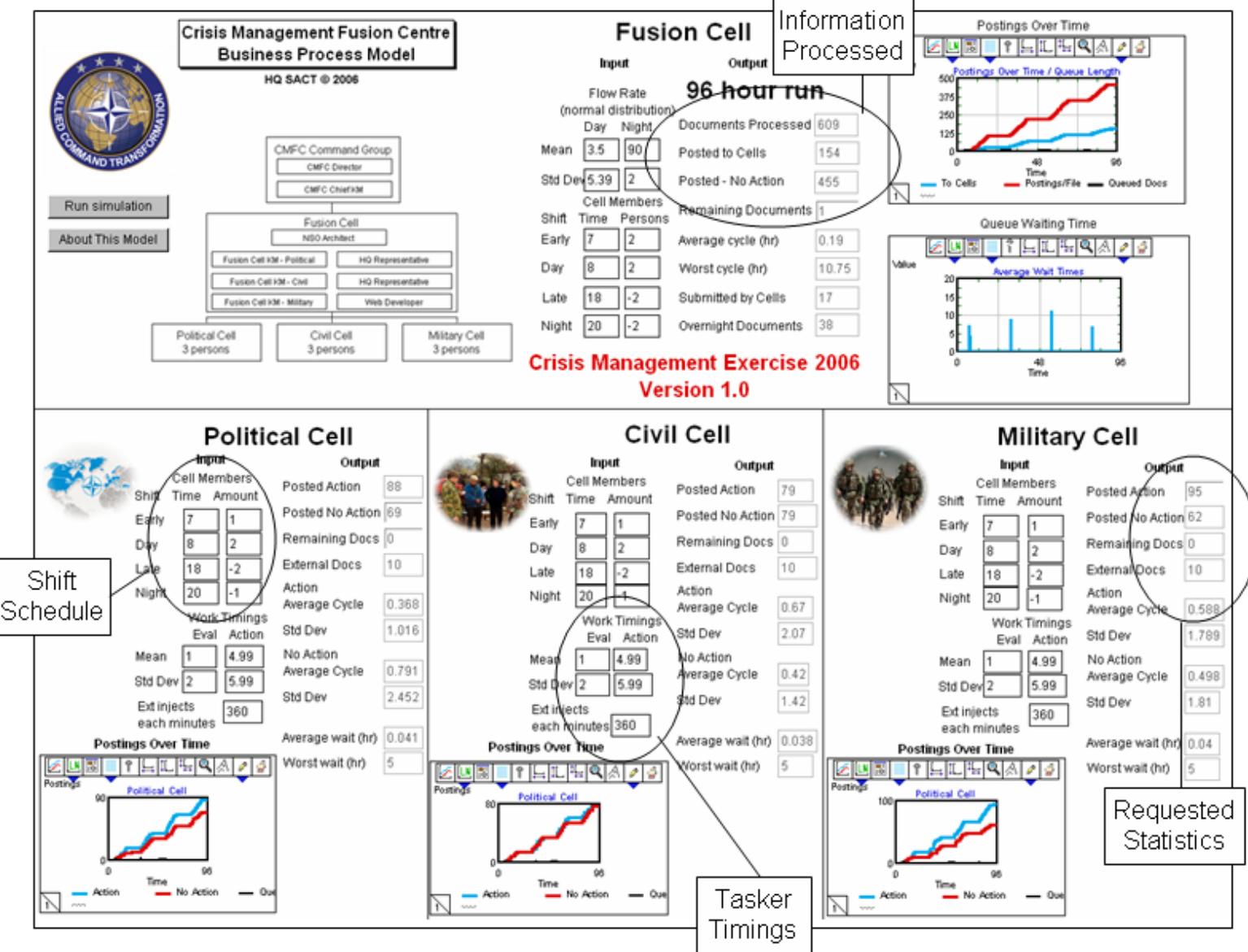
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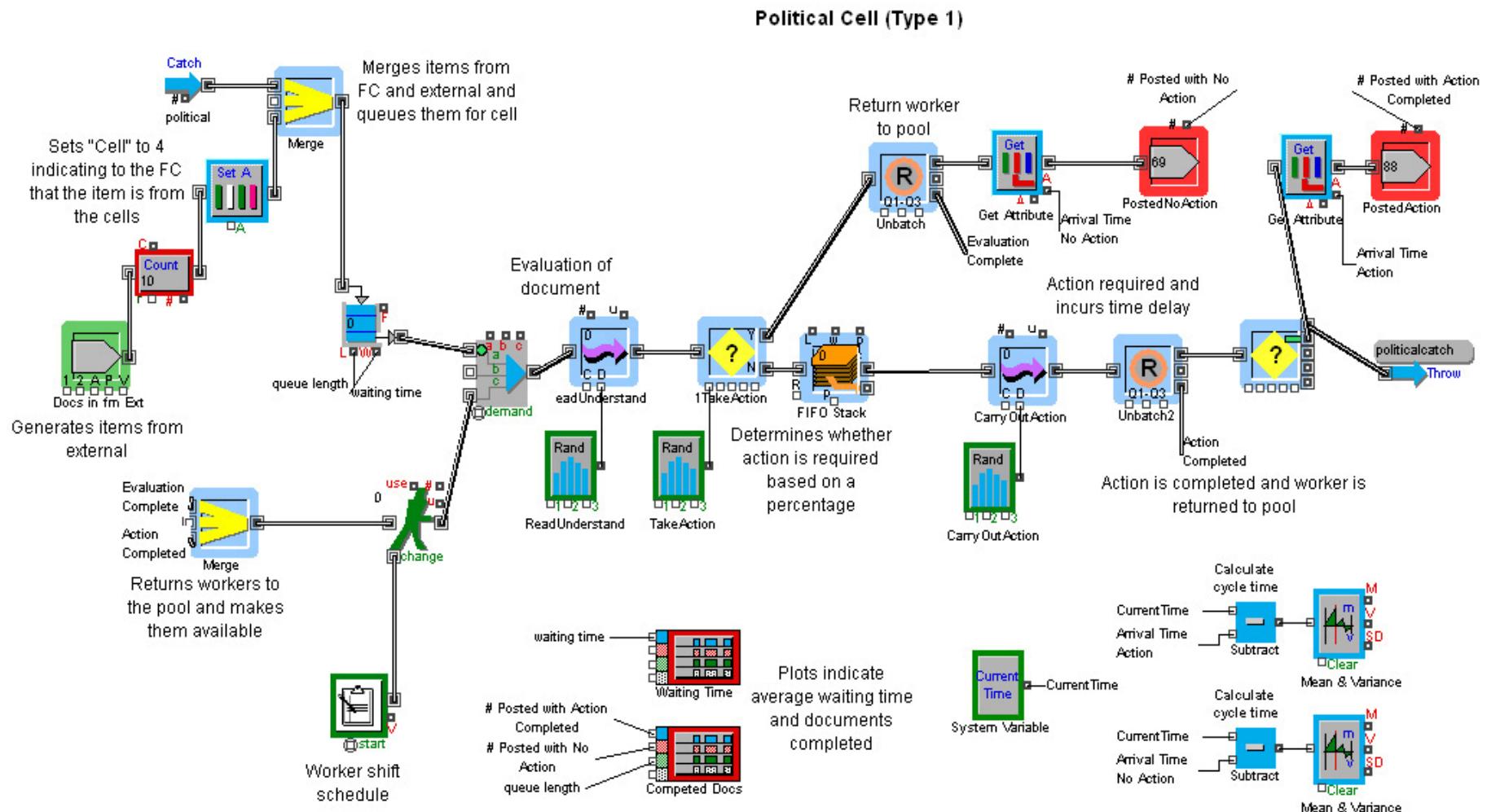


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Crisis Management Fusion Centre Model and Simulation



“Programming” in Extend™



CIMIC Experiment Campaign Plan

- One of ACT's first, coordinated, coherent, planned experiment series utilising M&S
- Focused on information collaboration/sharing
- Using industry to provide the battlelab and synthetic environment
- Being used as a use case for the NIAG Industrial Battlelab Study



CIMIC Experiment Method

- Initial high level view of required information flows between and amongst NATO and NNOs
- Uses DODAF architecture
- Identify enabling processes
- Real world visualization of a specific parts of this model to facilitate discussion with NNOs
- Engage with NNOs to elaborate/refine the assumptions in the model
- Experiment on a variety of possible organizational approaches



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Lessons Identified

- Inexpensive M&S tools such as Extend™ can help to achieve speedy innovation
- Concept developers need M&S for their work
- Showing concept developers the drag and drop process building blocks of the model to help them visualise their concept
- Stakeholders need to be aware of the benefits of M&S
- Simulationists need to be integrated with other analysts
- Exercises are different from real life and the artificiality of the situation can have a severe effect on the simulation outcome and insights
- The ability to easily share the simulation is very powerful



An Early Assessment

“I think you are taking an approach to modelling that is not only effective, but also has the possibility of giving a greater quality and variety of information than one could get from the large, inflexible models that one sees in use in some other places. This is really encouraging and I’m glad to see that it is happening.”

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